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## LICHEN DISTRIBUTION IN THE SANTA CRUZ PENINSULA, CALIFORNIA

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The Santa Cruz peninsula, California, forms a rough triangle extending in a northwesterly direction from Monterey Bay on the south to the Golden Gate at the north, a distance of ninety miles or more. In breadth it varies from about thirty-five miles at the widest portion to perhaps six miles near the northern end. Laved on the west by the Pacific, its eastern boundary is formed by San Francisco Bay and the broad, originally treeless Santa Clara-San Benito valley; while at the southeast the Pajaro cuts its way through the range and separates it from the Gabilan range.

Rising from sea-level along most of its border, it reaches at its highest point an elevation of 3793 feet and embraces within its limits every variation between the dense, unbroken redwood forest and the bare, sea-girt rock, the cloud-swept mountain crag, and the vast expanse of monotonous salt marsh.

Separated thus from the adjacent country and having such a diversified surface, it forms a natural biological region, well known both to the zoologist and the botanist. Though lichens are notorious for their wide geographical distribution, a study of the Santa Cruz lichens shows that they too are affected by the comparative isolation of the peninsula.

In addition to its possession of a number of endemic forms, one of the most interesting features of the lichen flora of the Santa Cruz peninsula is the commingling of boreal or alpine, temperate, and tropical species. At the same time, there is a remarkable absence of certain lichens which we should naturally expect to find in the region. That no species of the genus *Graphis* should be found, and that *Cladonia rangiferina* and all forms of the genus *Stereocaulon* are absent, is an anomaly that as yet seems baffling, since forms ordinarily associated with all these are common.

But the mingling here of lichens typical of different phytogeographical regions can be explained, I believe, by a study of the

climatology of the Pacific Coast and of the Santa Cruz peninsula in particular, recognizing at the same time that the area under discussion is really an aggregate of a number of minor biological areas, each possessing distinct physiographic, faunal, and floral features, and marked by its own typical lichen species.

Most people, in a general way, have the idea that California has a subtropical climate, and that name is often applied to it. In reality, owing to its great area and wonderfully diversified topography, California has many climates, but the typical Californian climate is, more than that of any other part of the United States, a true cool temperate climate; and it is to the rather cool but remarkably equable temperature conditions that we primarily owe the interesting intermixture of lichens typical of unlike life-regions.

As typical of the temperature of the Santa Cruz peninsula I quote the following averages for the twelve months of the year, as fixed by observations at San Francisco extending over more than half a century: "January, 52.2° F.; February, 52°; March, 54°; April, 55°; May, 57°; June, July, and August, each 59°; September, 60.8°; October, 60°; November, 56°; December, 52°."

These temperatures will favor the boreal or alpine forms such as *Gyrophora polyphylla*, *Evernia vulpina*, *Lecidea caeruleo-nigricans*, *Rhizocarpon geographicum*, and others of like character; while at the same time they will permit of the migration from warmer regions of various species of *Ramalina*, *Dendrographa*, *Dirina*, *Lecanactis*, *Schismatomma*, etc.

While the temperature conditions of the whole Santa Cruz peninsula are quite uniform, the annual rainfall shows great variation in different localities, ranging from 50 or 60 inches at Boulder Creek, and even more in the Big Basin, to 13 or 14 inches at Stanford University.

For detailed statistics on this whole matter, however, one must refer to Professor ALEXANDER MCADIE'S valuable work upon *The Climatology of California*.

A study of the lichen flora of the Santa Cruz peninsula shows that it is more or less sharply divided into a number of biologic areas, which may be roughly classified as the maritime, foothill, chaparral, mountain-forest, and mountain-peak areas.

The maritime area is sharply defined, more so in fact than any of the others, and includes not only a narrow strip of land all along the coast but also all of the northern tip of the peninsula down to and including the San Bruno mountains. Most of this area is of course of low elevation, but in the northern part of San Mateo County, where the broken hills of San Francisco culminate in San Bruno mountain, it extends to an altitude of more than 1300 feet.

This maritime region possesses the most equable climate of the peninsula, and also perhaps the highest daily average of humidity. It is characterized by relatively cold, windy, and foggy summers, the fogs mitigating the dryness of the rainless summer months; the winters are comparatively clear, sunshiny, with less precipitation than the redwood forests farther inland, and much warmer than in the other areas. At several points along the coast a whole winter often passes without the temperature once falling to 32° F.

This area may (in a large way) be considered as a part of the belt which extends southward to the tropics, and beginning again on the coast of Peru reaches far to the south of Valparaiso, Chile. It is a region in the main of slight rainfall and very moderate range of temperature, and it is therefore not surprising that we find a number of rock or earth lichens common alike to the shores of California, Peru, and Chile, yet unknown except on the Pacific coast of the Americas.

I have no means of knowing how far to the north of the Golden Gate these forms go, but most of them, including those originally described by TUCKERMAN from the San Francisco Bay region, seem to become more luxuriant as we go farther south, though I have seen none from below Guadalupe Island, Lower California. This would seem to indicate that such forms may be regarded as migrants from regions lying nearer to the tropics, and that the Golden Gate is very near to their northern limit, if indeed they go beyond it. In this category we may place most of the characteristic lichens of the maritime region.

The characteristic lichens of this area do not occur in any of the other areas, and in that respect it is the most strongly marked of them all. Some of the more important are as follows:

*Arthopyrenia halodytes* (Nyl.) Oliv.; *Buellia halonia* (Ach.) Tuck.; *Dendrographa minor* (Tuck.) Darbish.

***Dirina franciscana*** A. Zahlbruckner, n. sp.—Thallus effuse, of thick, rounded, irregular tuberculate areoles, uniform crustaceous, sub-cartilaginous, forming heaped patches. Color varying from yellowish or brownish yellow to a dingy ashy gray, the last most common; K—; C—.

Apothecia numerous, of medium size, rounded elevated, sessile; surface of disk minutely granular, ashy-gray pruinose; the thalline margin thick, prominent, white, obtuse, soon flexuous, often intricately so; epithecium dark,  $56\ \mu$  high; hypothecium black, thick,  $140\ \mu$  high, blue or bluish with I; paraphyses typical of the genus, thecium wine-red with I; asci clavate, straight or curved, long-stalked,  $\frac{70-134.5}{16.8-22.4}\ \mu$ ; spores eight, colorless, fusiform, straight or slightly curv.d, quadrilocular,  $\frac{23.8-33.5}{5-8}\ \mu$ .

On rocks 50 to 75 feet above the sea at Point Lobos, San Francisco, growing with *Dendrographa minor*.

Near *Dirina repanda* of Europe and Northern Africa, but with a thicker and differently colored thallus and with different spores.

***Lecanactis Zahlbruckneri*** Herre, n. sp.—Thallus effuse, of small, irregular (sometimes plicate) squamules which at first are scattered but soon become a thick, uniform, tartareous crust. Color a more or less evident rose-pink which soon fades out in herbarium specimens, leaving them whitish or ashy gray.

Apothecia small, round, sessile, becoming convex; black, the disk gray-pruinose, but eventually naked; the proper margin prominent but finally excluded. Epithecium dark or black, thick, 45 to  $50\ \mu$  high, blue with I; hypothecium black, broad, 42 to  $60\ \mu$  high; paraphyses typical of the genus, thecium brick-or vinous-red with I; asci clavate, straight or curved, sometimes pointed at tip,  $\frac{78-106}{16.8}\ \mu$ ; spores eight, colorless, fusiform, straight or slightly curved, quadrilocular,  $\frac{19.6-28}{5-7}\ \mu$ .

Rare on maritime rocks, 50 to 75 feet above the sea, at Point Lobos, San Francisco. Associated with *Dendrographa minor*, *Arthopyrenia halodytes*, and *Trentepohlia* sp.

*Lecanora Bolanderi* Tuck.; *L. pinguis* Tuck.; *L. phryganitis* Tuck.; *Opegrapha saxicola* Ach.; *Parmelia Herrei* A. Zahlbr.; *P. Borreri* Turn.; *P. perlata* (L.) Ach.; *Pertusaria multipuncta* (Turn.) Nyl.; *Physcia erinacea* (Ach.) Tuck.; *Placodium coralloides* Tuck.; *Ramalina ceruchis* (Ach.) DeNot.; *R. ceruchis cephalota* Tuck.; *R. combeoides* Nyl.; *R. homalea* Ach.; *Rinodina radiata* Tuck.

The foothill region comprises all that territory between San Francisco Bay and the mountains proper, south of San Bruno mountain, and extends from sea-level to a height of approximately 1000

feet. On the Pacific side it is either very narrow or non-existent, but on the eastern side of the peninsula it extends as far south as Monterey Bay. A park-like oak forest is characteristic of the lower part of the region, and on these trees is a lichen flora remarkable for its variety and luxuriance. While but few lichens are confined to this area, many reach here their greatest development. Probably every tourist is struck with the appearance of the "lace lichen," *Ramalina reticulata* (Noehd.) Krempelh., which decks the trees much as "Spanish moss" clothes the live oaks of the Gulf Coast. Other noticeable lichens are:

*Collema nigrescens* (Huds.) Wainio; *C. vespertilio* (Ltf.) Wainio; *Evernia prunastri* (L.) Ach.; *Lecanora subfusca* (L.) Ach.; *L. varia* (Ehrh.) Nyl.; *Lecidea granosa* Tuck.; *L. granulosa phyllizans* A. Zahlbr.; *Leptogium chloromelum stellans* Tuck.; *L. palmatum* (Huds.) Mont.; *Pannaria lepidiota cyanolepra* Tuck.; *P. lepidiota coralliphora* Tuck.; *Parmelia soledica* Nyl.; *Placodium cerinum* (Hedw.) Naeg. & Hepp.; *P. ferrugineum* (Huds.) Hepp.; *Physcia pulverulenta isidiigera* A. Zahlbr.; *Ramalina Menziesii* Tuck.; *Thelochistes lychneus laciniosa* (Schaer.).

The chaparral belt is not sharply delimited by contour lines or elevations, but depends upon climatic as well as physiographic features, the characteristic angiosperms of the chaparral being well-marked xerophytes. Hence we may have chaparral occurring on dry, barren hill-tops as low as four hundred feet, while we find more or less of it all the way to the summit of the Santa Cruz mountains. Very few lichens are exclusively chaparral, but where the conditions were favorable to such movement many conspicuous species have migrated from the adjacent forests. Certain components of the chaparral, such as the manzanitas, are almost wholly devoid of lichens ordinarily, because of their thick evergreen foliage and exfoliating bark. Others, as *Ceanothus*, *Cercocarpus*, and the scrub oaks, are conspicuous for their dense growth of lichens. The chief lichens in this formation are:

*Cetraria californica* Tuck.; *Cladonia verticillata* Hoffm.; *Lecanora pallescens* (L.) Schaer.; *Parmelia enteromorpha* Ach.; *Ramalina farinacea* (L.) Ach.; *Usnea plicata* (Ach.) Nyl.; *U. dasypoga* (Ach.) Nyl.; *U. florida* (L.) Ach.

The typical mountain forest of the Santa Cruz peninsula is the redwood and Douglas spruce formation, though much of the forested

area is given over to a growth of oaks, madrone, and other trees. In the redwood formation, sheltered by the dense canopy overhead, the lichens are but little affected by the frosts of winter, while the heavy summer fogs counteract the effect of the summer drouths. Having such favorable life-conditions for lichens, we may regard this region as the distributing center from which the chaparral has been stocked, while the foothill area has also largely been supplied in the same way. Arboreal forms such as the Stictaceae and certain Parmelias reach their highest vegetative and reproductive development in the dense redwood forests; while many others living on the earth or mosses are fertile and well grown only in the forests at 2000 feet or above, though they may descend in the foothills to as low as 150 feet. In this connection it may be well to call attention to the fact that the forests cover a much smaller area than formerly. For the last half-century the ax of the lumberman and forest fires have been actively engaged in the process of deforestation, and another generation may see many of the characteristic plants of the redwood forest extinct except within the limits of the Big Basin, which the state has purchased and set aside for a state park. Some of the more striking lichens of the forests are:

*Alectoria jubata* (L.) Tuck.; *Cetraria ciliaris* (Ach.) Tuck.; *C. lacunosa stenophylla* Tuck.; *Cladonia macilenta* (Hoffm.) Nyl.; *Leptogium albociliatum* Desmaz.; *L. californicum platynum* Tuck.; *Nephromium helveticum* Ach.; *N. lusitanicum* (Schaer.) Nyl.; *N. tomentosum rameum* Nyl.; *Parmelia enteromorpha* Ach.; *P. perforata* (Wulf.) Ach.; *P. tiliacea* (Hoffm.) Ach.; *Peltigera canina membranacea* (Ach.) Nyl.; *Pertusaria Wulfenii* DC.; *Lobaria pulmonaria* (L.) Hoffm.; *L. scrobiculata* (Scop.) DC.; *Sticta anthraxis* Ach.; *S. fuliginosa* (Dicks.) S. Gray; *S. limbata* (Sm.) Ach.; *Sphaerophorus globosus* (Huds.); *Usnea longissima* Ach.; *U. californica* Herre.

By the mountain-peak area is meant the masses of exposed rock which may occur about the heads of heavily forested cañons, as well as the bare and rocky mountain peaks extending above the forests and chaparral. The lichens of this area are typically saxicolous, and while they may occur throughout the other formations wherever there is sufficient area of rock surface, some are found only along the highest mountains, swept by raw, bleak winds and exposed to a great diurnal as well as annual range of temperature. In summer this may rise to a sun temperature of 150° F. or more, and in winter may

descend to 20° F. or thereabouts, accompanied by more or less snow. These conditions of course can be met only by lichens specially adapted for such a life, of marked xerophytic structure, and there is no such enormous thalline development as is observed in the foothills or redwood formation. The lichen flora of this region, however, is not below that of any of the others in either number of species or of individuals. Important lichens of this region are:

*Collema plicatile* Ach.; *Gyrophora diabolica* A. Zahlbr.; *G. phaea* (Tuck.) Herre; *G. polyphylla* (L.) Turn. & Borr.; *Lecanora muralis diffracta* Fr.; *L. calcarea* (L.) Sommerf.; *L. sordida* (Pers.) Th. Fr.; *L. upsaliensis* Nyl.; *Lecidea caeruleo-nigricans* (Lightf.) Schaer.; *L. auriculata* Th. Fr.; *L. polycarpa* Fr.; *Rhizocarpon geographicum* DC.; *Parmelia conspurcata* (Schaer.) Wainio; *Verrucaria terebrata* (Mudd).

The lists published are merely some of the most conspicuous of each area and are by no means exhaustive. In the author's herbarium are more than 200 named species and sub-species of lichens which he has collected in the Santa Cruz region, with perhaps nearly a hundred more as yet unstudied or not satisfactorily determined. It is believed that the lichen flora of the region under discussion will be found to include more than 300 species and sub-species.

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